(12) UK Patent Application (19) GB (11) 2 185 866 (13) A

(43) Application published 29 Jul 1987

(21) Application No 8531412

(22) Date of filing 20 Dec 1985

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(51) INT CL⁴
H02J 7/00 H01R 13/453 13/631 // B60L 11/18 H01R 13/15 13/703

(52) Domestic classification (Edition I):
H2H BCA BCD BCH BCJ BD
H2E 239 261 279 CAA CD DBA HAD
U1S 1820 2078 H2E H2H

(56) Documents cited

GB A 2080550	GB 0955151	US 4158802
GB 1519855	WO A1 84/04212	US 3898547
GB 1282974	US 4347472	US 3529229

(58) Field of search
H2H
Selected US specifications from IPC sub-classes B60L H02J

(54) Charging battery-powered vehicles

(57) In response to interengagement between a contact assembly (130), (Fig. 10), on the vehicle and a charging head (12), (Fig. 4), charging current is supplied to the charging head for recharging the vehicle's battery. The interengagement operates a microswitch (187), (Fig. 16A), on the vehicle whereby if a charge level monitor (208) indicates that recharging is required, a vehicle computer (204) energizes a relay (212) so that a signal is sent from the battery (206) via the charge head to unblock safety swiching means (214) whereby the charging head is supplied with charging current and charging is effected under control of a current limiter (210) on the vehicle. The interengagement also operates a microswitch (94) at the charge head, in response to which communication between the vehicle computer (204) and a charge head computer (205) is established. The vehicle drive system may be computer controlled for indexing of the vehicle between charge heads.

Interengagement of the vehicle contact assembly and the charge head is facillitated by providing guide members (196), (198), (Fig. 10) on the vehicle and providing a spring-biased self-aligning mounting for the charge head (Figs. 5, 6) which allows

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FIG.13A.

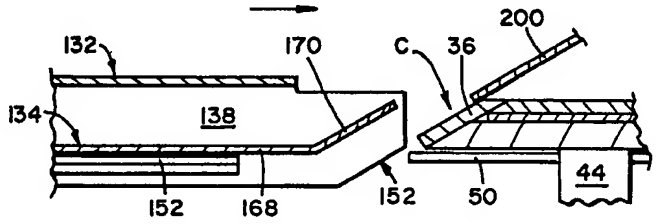


FIG.13B.

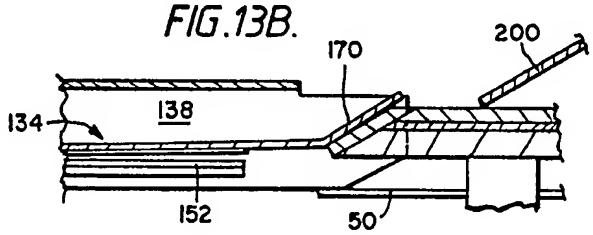
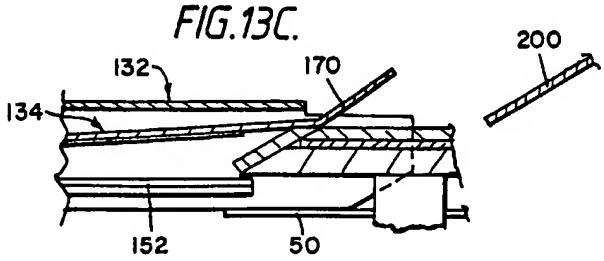


FIG.13C.



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the head to *a* rise and fall on a parallelogram linkage, *b* rotate about a vertical axis, and *c* to move horizontally laterally of the vehicle's direction of advance. During the interengagement cams 36, 152, on the charge head and vehicle respectively, lift cover plates 134, 50 to expose electrical contacts on the vehicle contact assembly and the charge head.

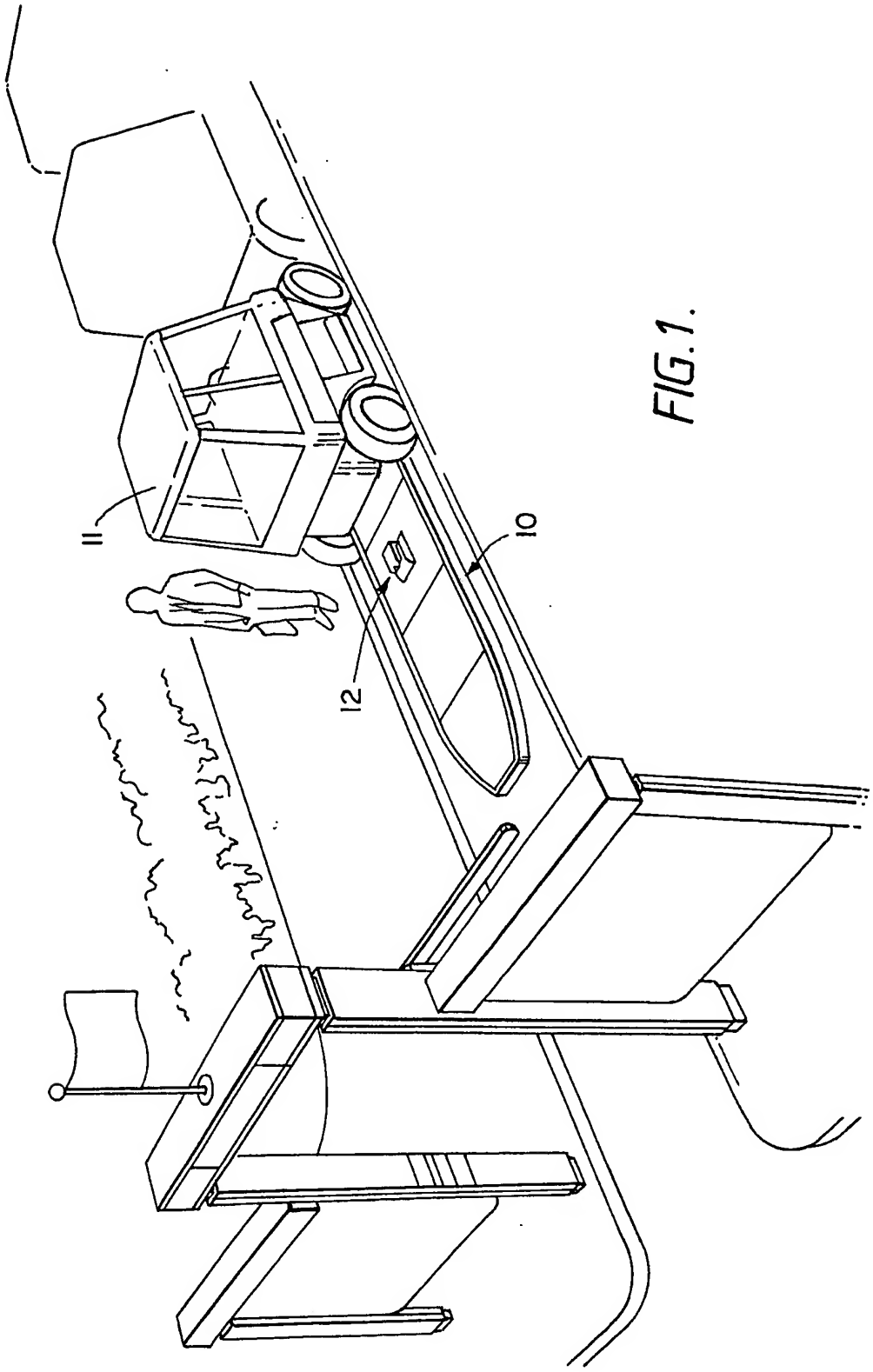

FIG.1.

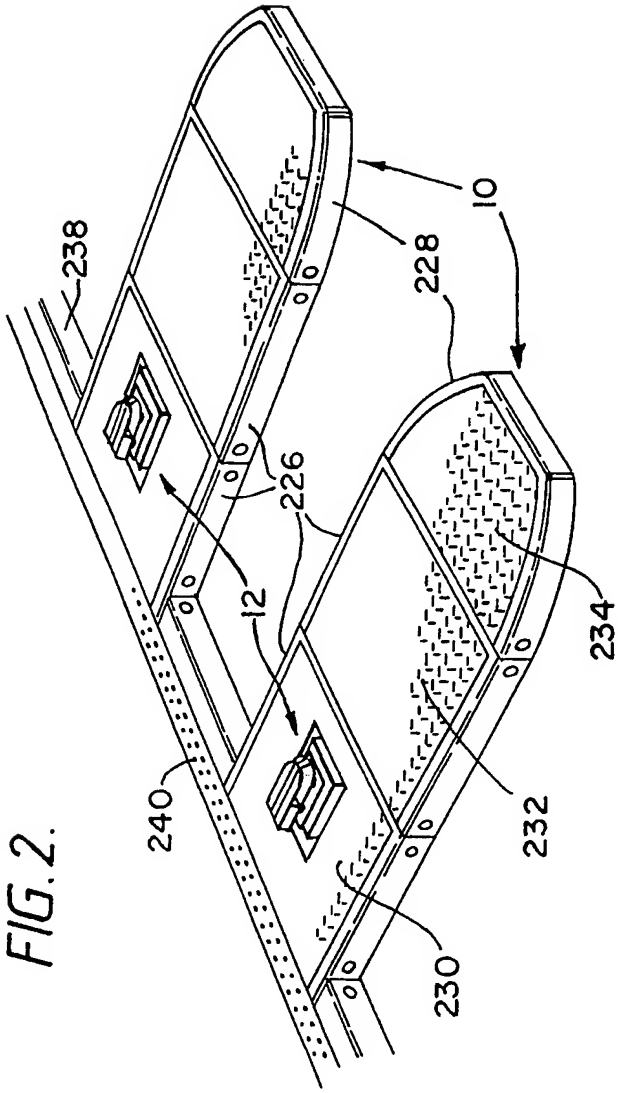

FIG. 2.

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FIG.3.

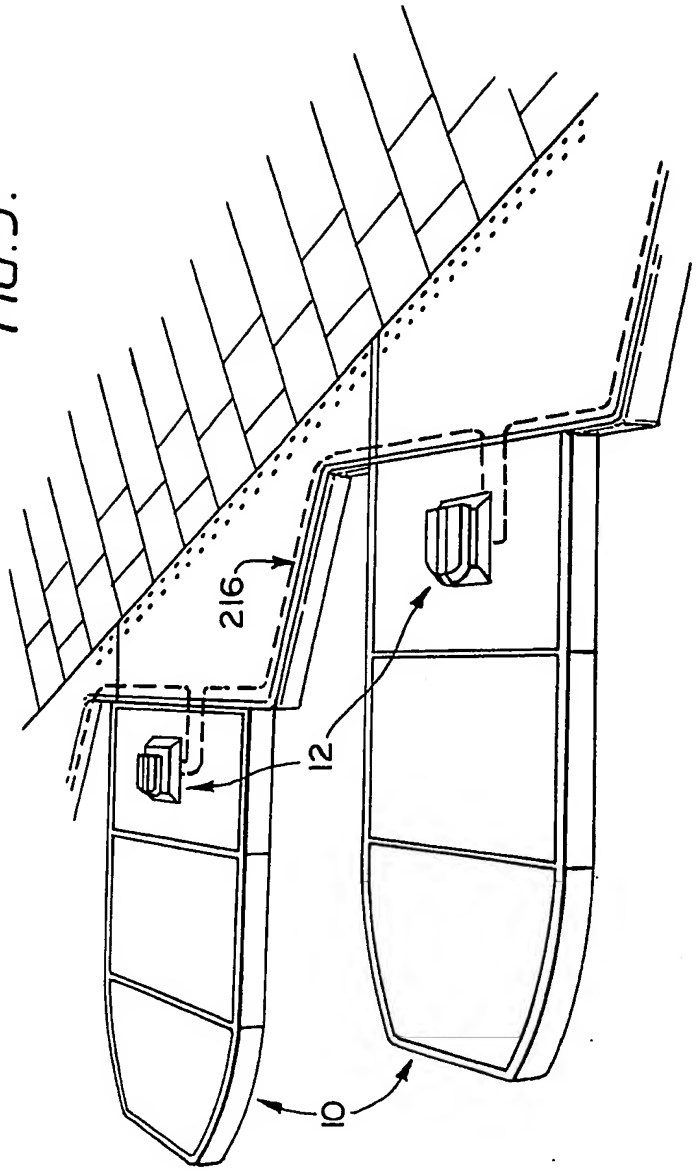

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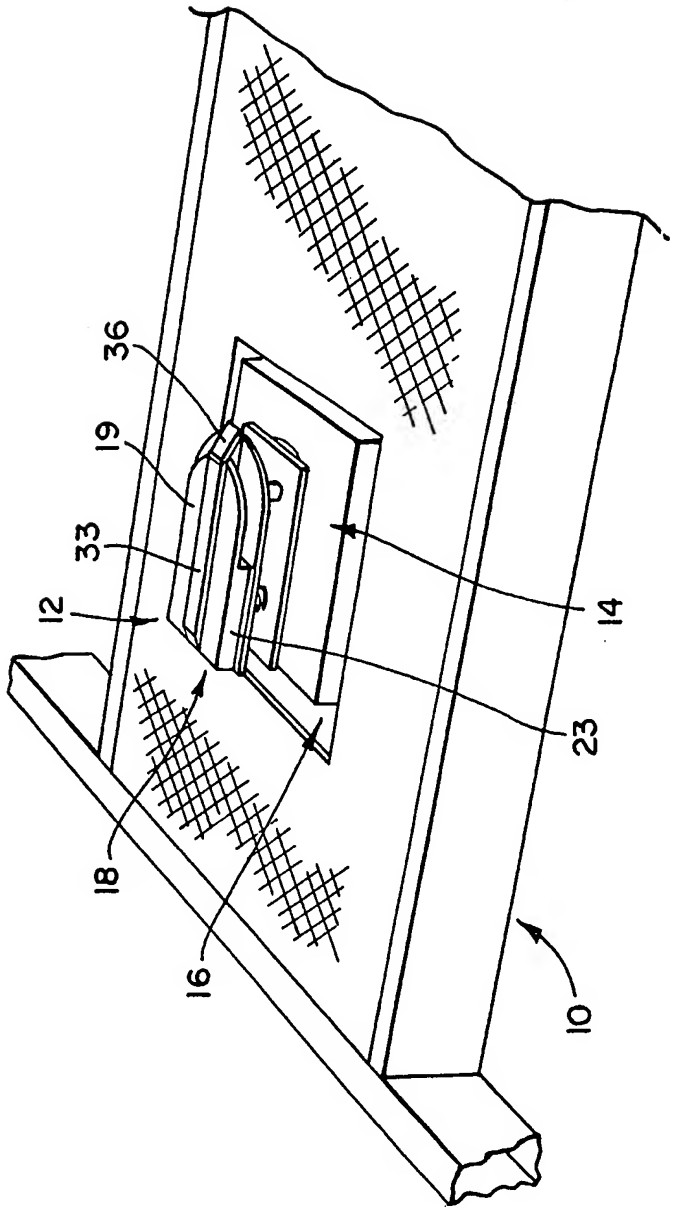
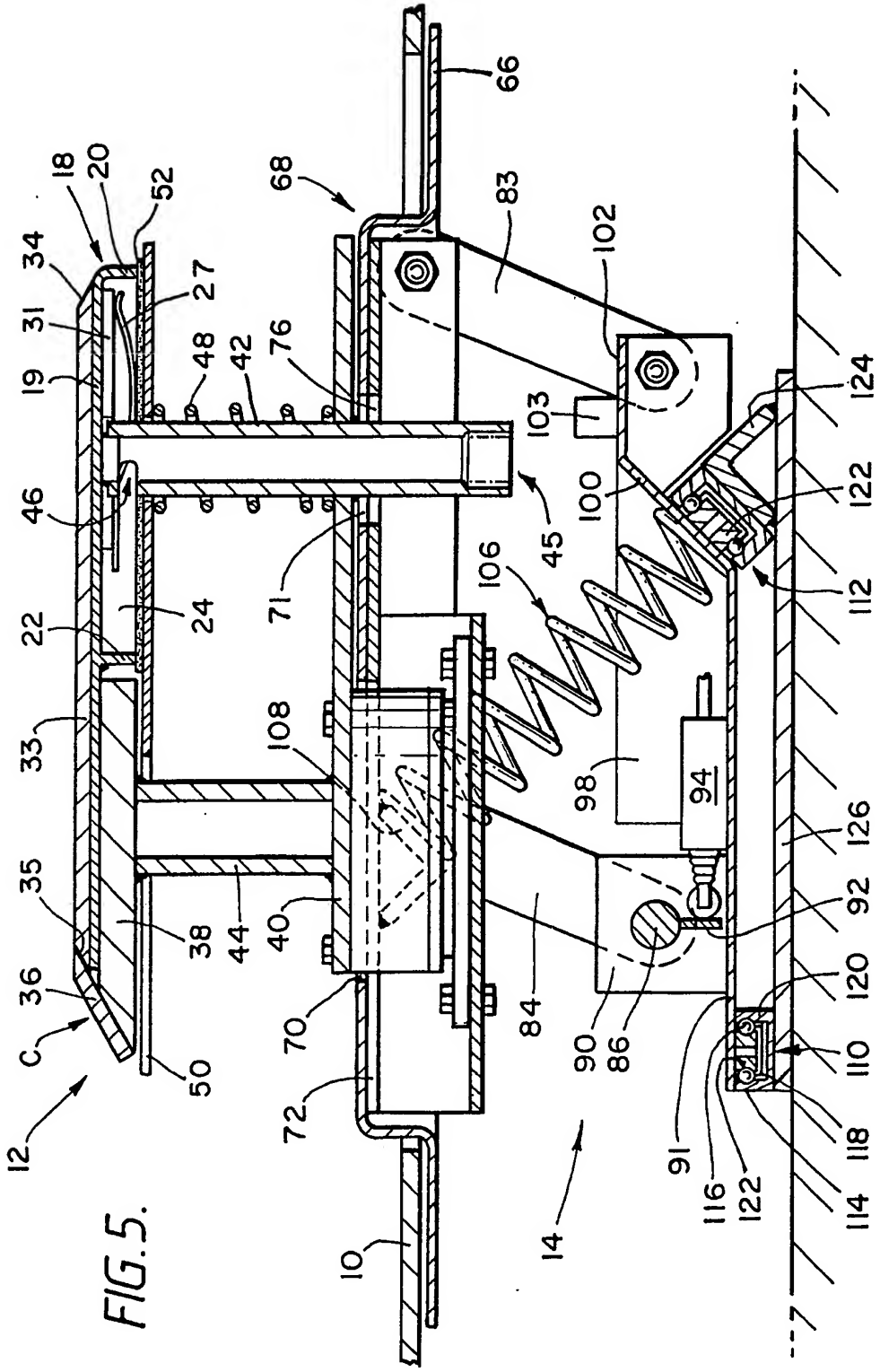
FIG. 4.




66
68
83
102
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112
22
24
71
108
33
98
94
126
35
38
44
40
92
36
70
84
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86
120
C
50
72
110
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116
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114
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14
10

FIG. 5.

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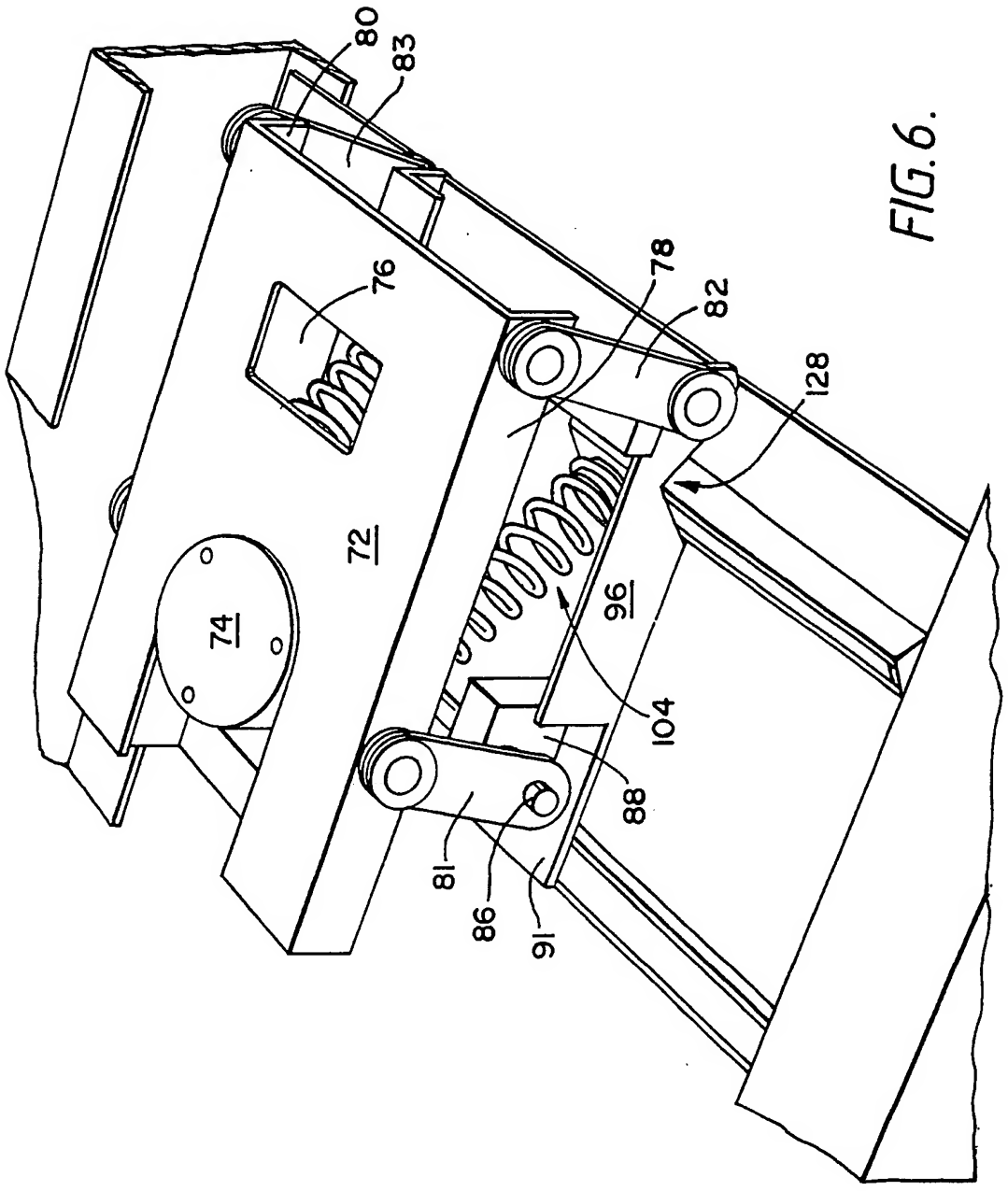

FIG.6.

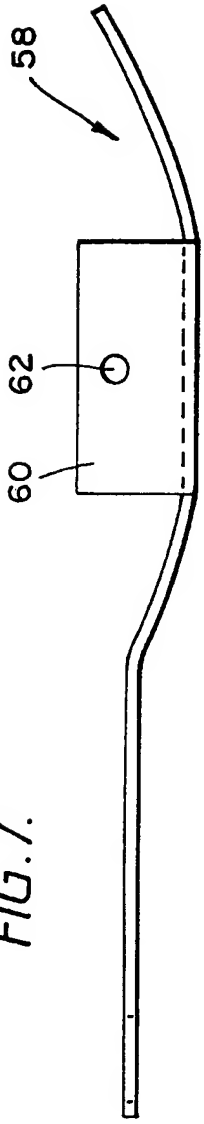

FIG.7.

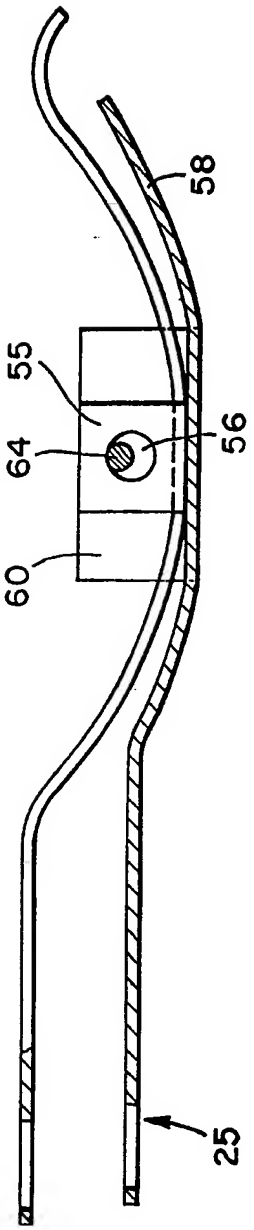

FIG.8.

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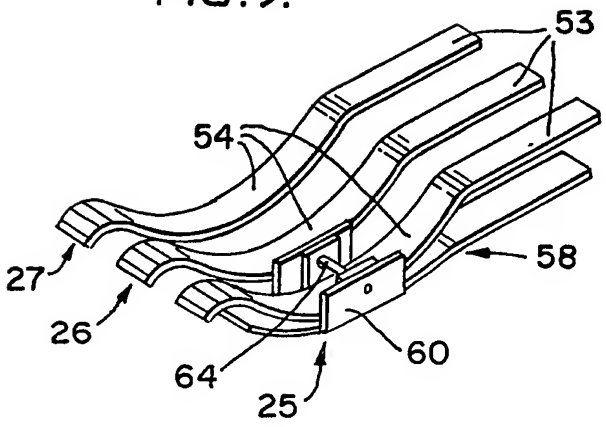
FIG. 9.



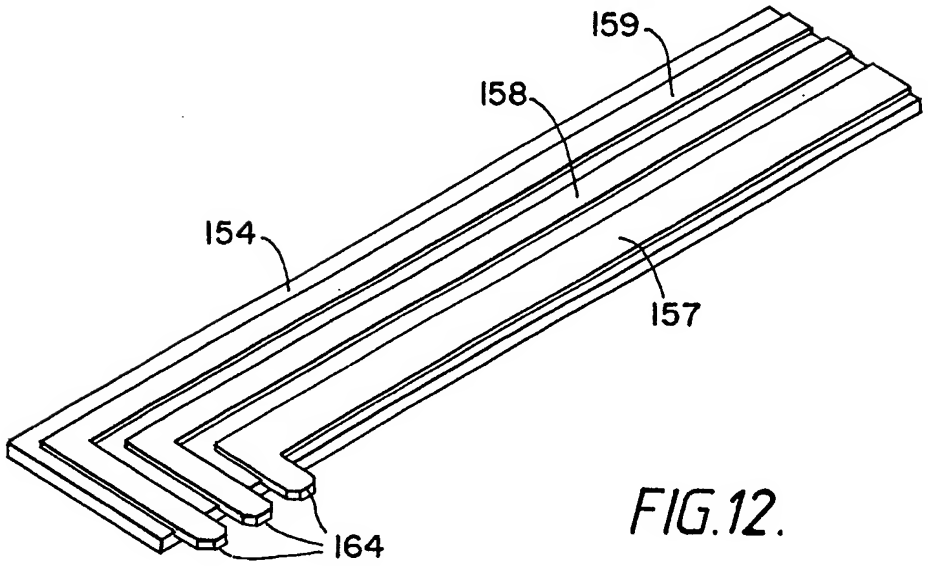


FIG. 12.

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FIG. 10.

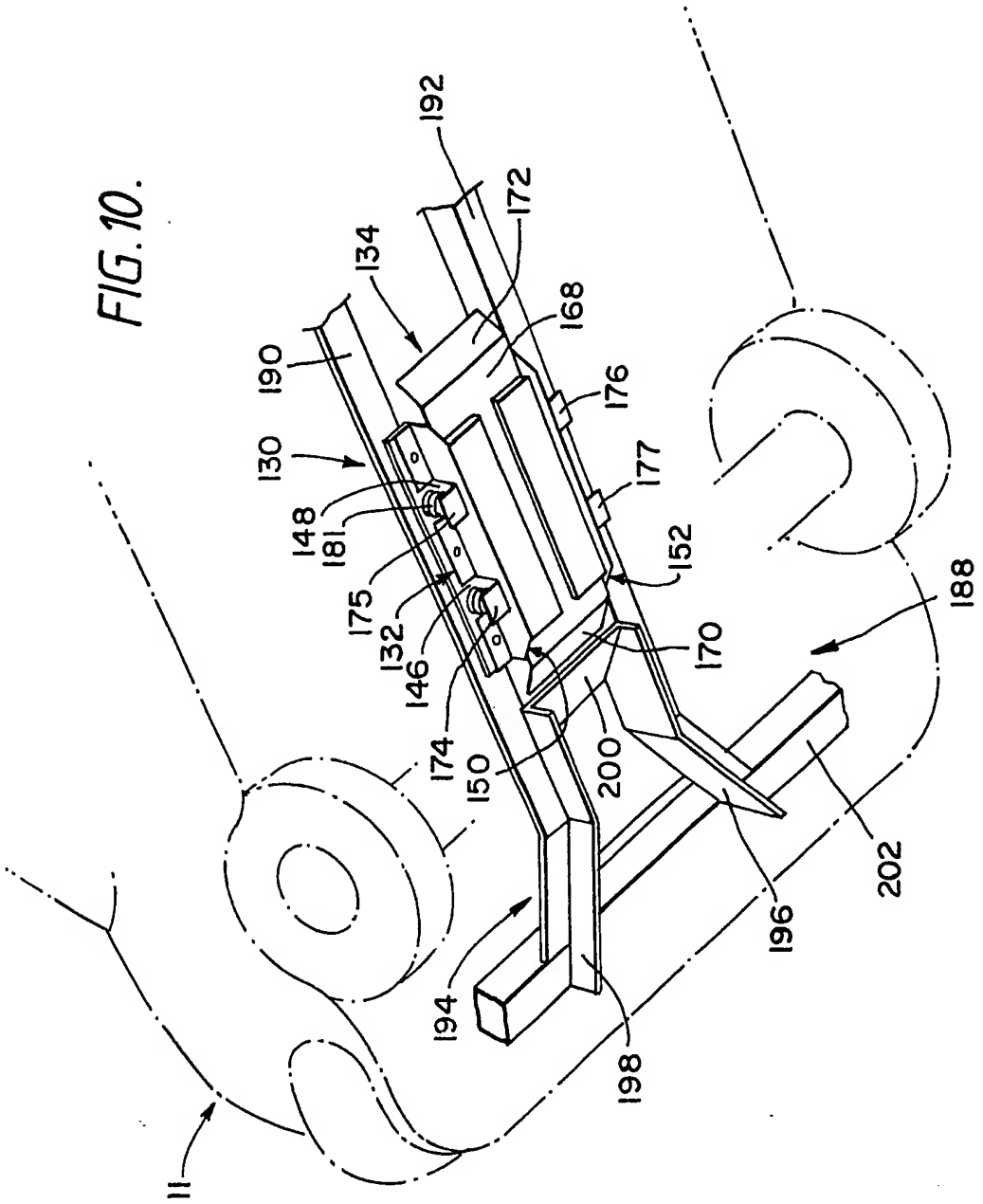
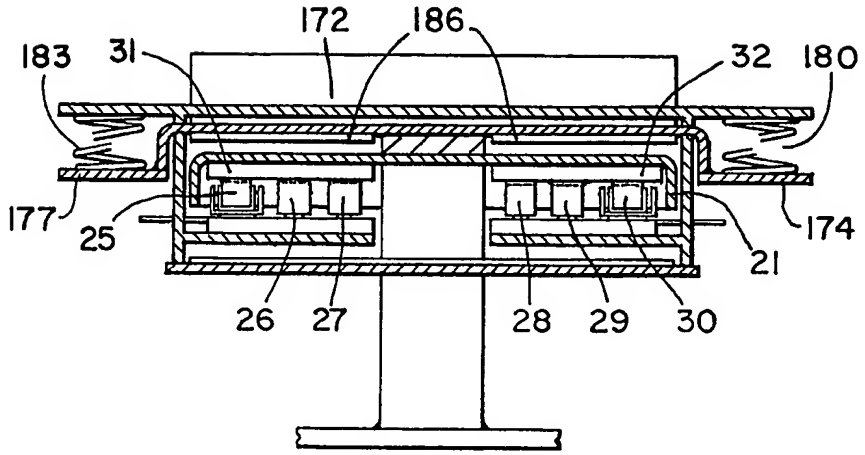


FIG.15.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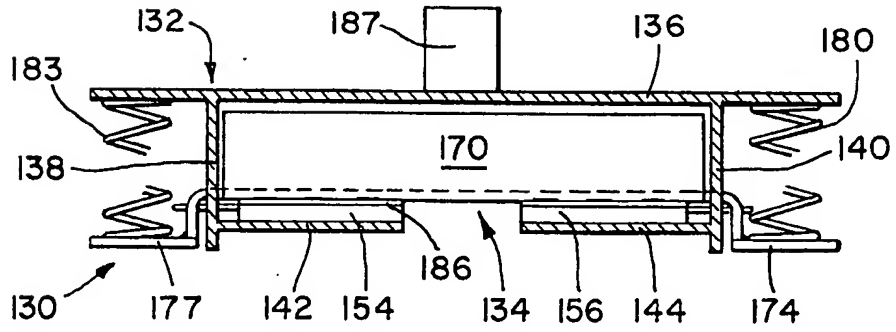
186
183
31
32
180
177
25
174
21
26
27
28
29
30

FIG.11.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183
170
138
140
186
130
177
142
154
134
156
144
174

FIG.13A.

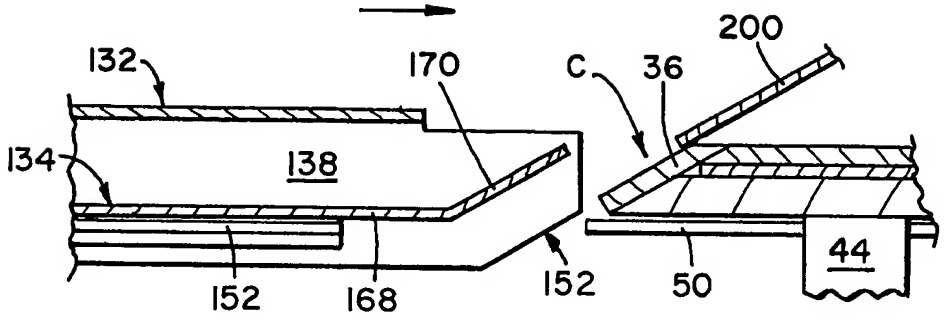


FIG.13B.

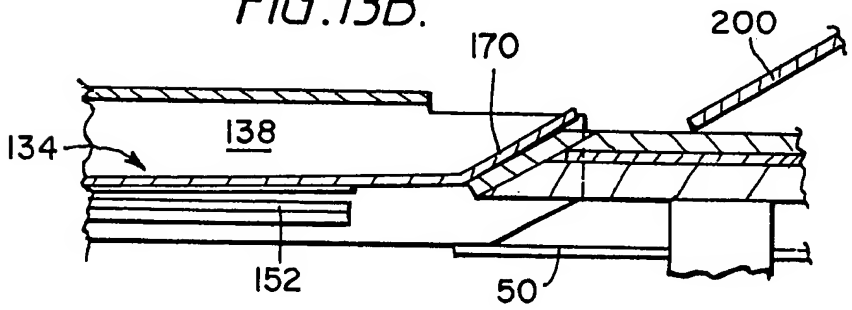
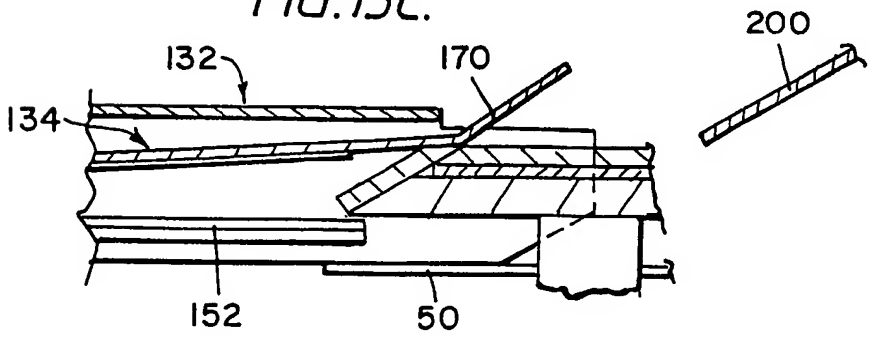


FIG.13C.



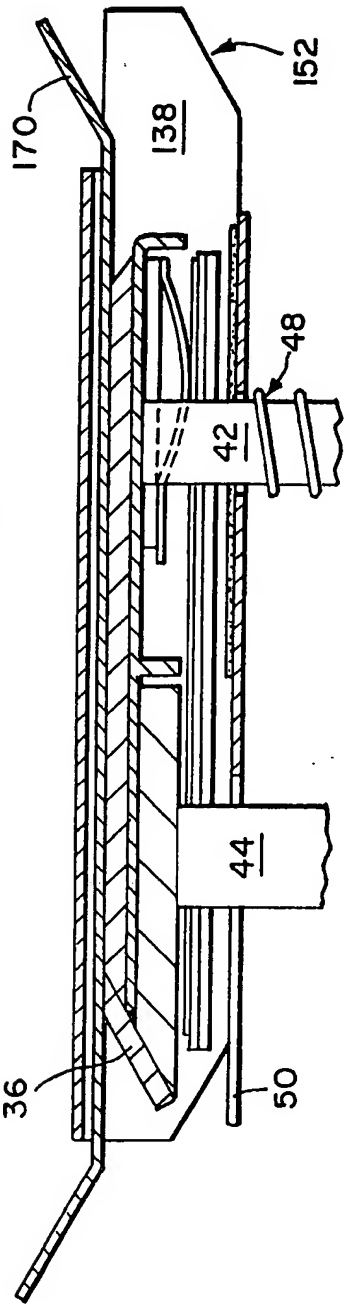


FIG. 14.

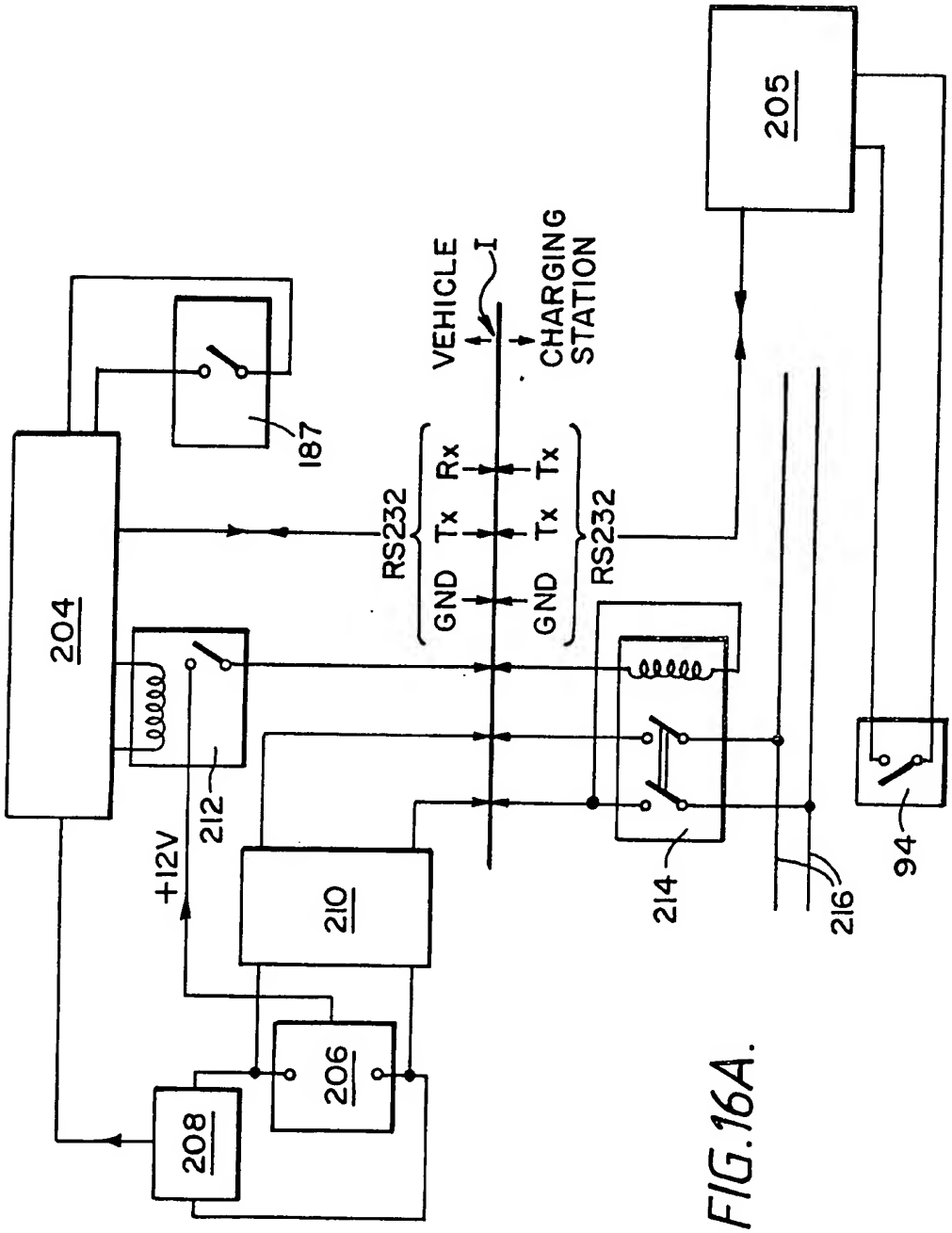

205
VEHICLE
CHARGING STATION
187
RS232
Rx
Tx
GND
Tx
GND
RS232
204
212
+12V
210
214
216
94
206
208

FIG. 16A.

FIG. 16B.

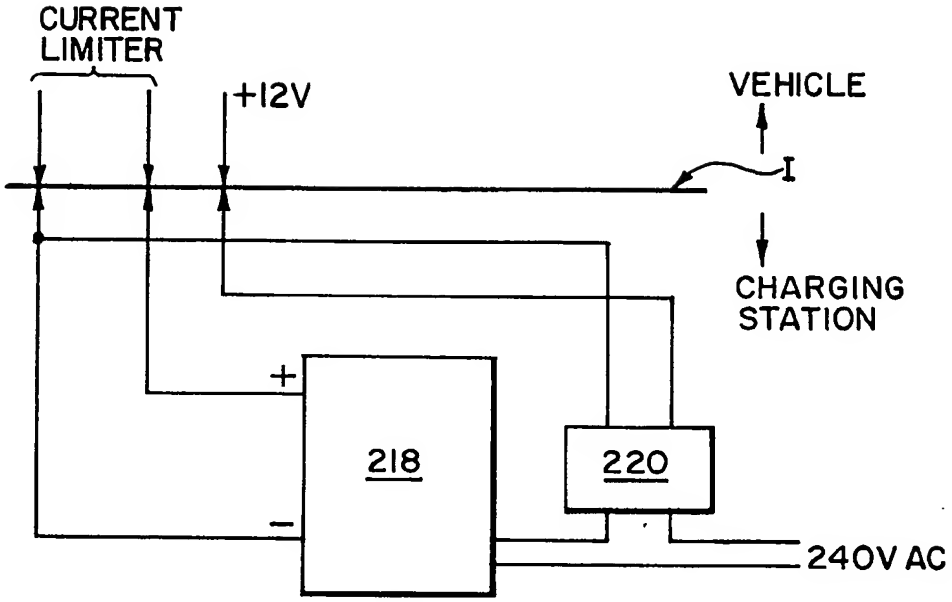

CURRENT LIMITER
+12V
VEHICLE
I
CHARGING STATION
+
218
220
240V AC

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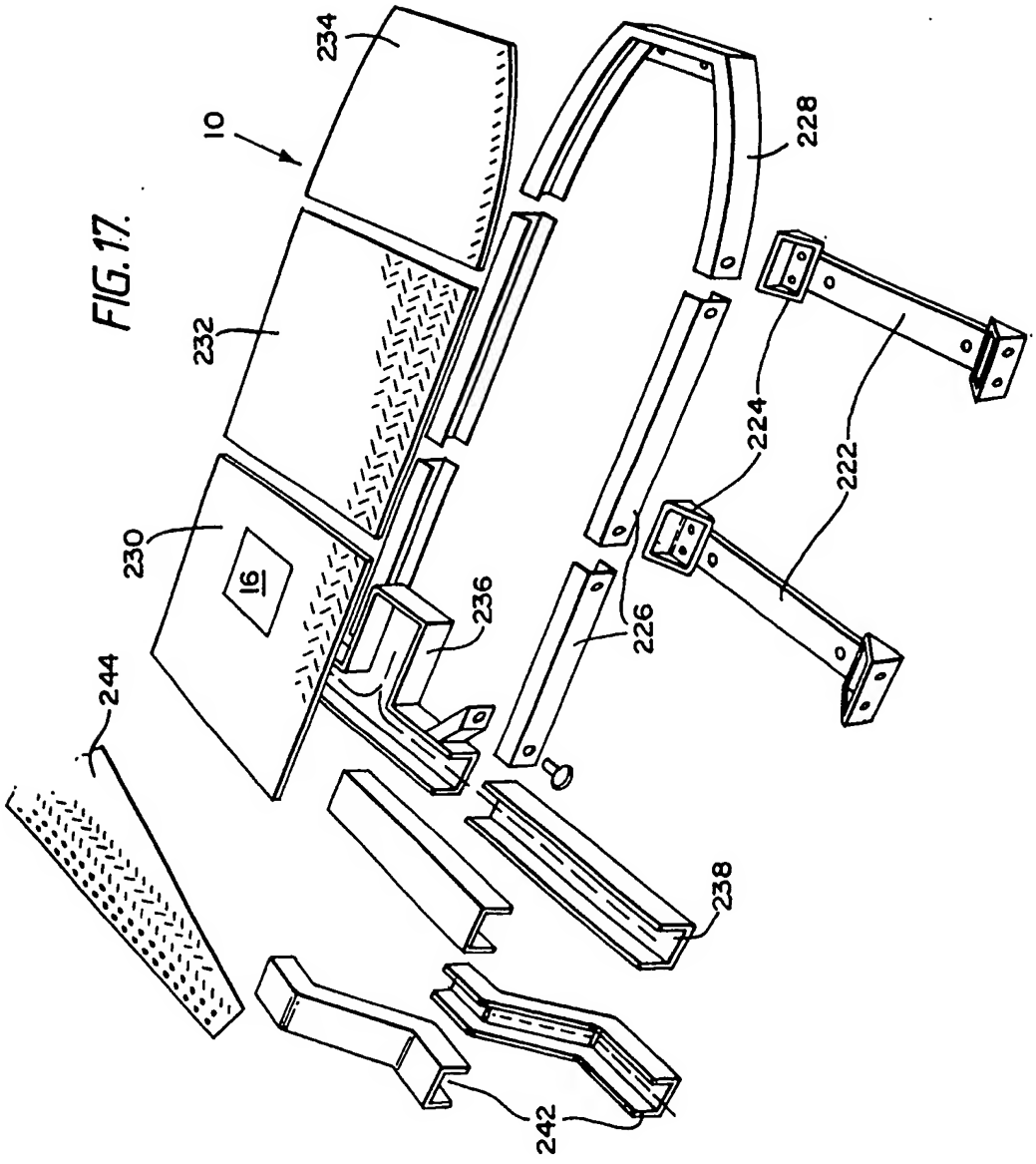
FIG. 17.



SPECIFICATION

A charging system for electrically powered vehicles

The present invention relates primarily to a charging system for electrically powered vehicles but has other aspects which will be described below.

It is known to recharge the battery of an electrically powered vehicle by using electrical leads which are manually connectable to a charging source. It is also known to provide electrical contact means on the top of such a vehicle configured for interengagement with an overhead structure such as a pantograph for the purpose of recharging the vehicle battery.

One aim of the present invention is to provide a system for charging an electrically powered vehicle which is safer and more convenient to use than known systems.

Accordingly, we provide a system for charging an electrically powered vehicle comprising a vehicle contact assembly mounted on the vehicle and a charging head associated with charging means, the vehicle contact assembly and the charging head both comprising electrical contact means, wherein the vehicle contact assembly and the charging head are interengagable to provide a charging connection and wherein the system is arranged so that the interengagement of the vehicle contact assembly with the charging head causes electrical power to be supplied to the charging head from the charging means to initiate charging.

An advantage of a charging system according to the present invention is the safety feature that no power is supplied to the charging head unless a vehicle is present at the charging head.

Preferably, the vehicle comprises means for supplying a signal to the charging head to initiate charging. In the preferred embodiment, the vehicle is battery powered and the signal supplying means comprises the vehicle battery. In the particular embodiment to be described, the means for supplying said signal is controlled by a computer onboard the vehicle.

In the embodiment to be described, safety switch means are associated with the charging head which safety switch means is caused to be closed when the vehicle contact assembly interengages the charging head so as to complete a charging circuit. The safety switch means may comprise a relay. Optionally, a mechanical relay and/or a solid state relay may be employed.

Preferaby, a charge level monitor is provided for sensing the the battery charge level, which charge level monitor is connected to a computer onboard the vehicle.

Additional switch devices, which may be in the form of microswitches, may be provided. In particular there may be a first switch device associated with the vehicle contact assembly and adapted to be activated during interengagement of the vehicle contact assembly and the charging head. The first switch device may cause a signal to be sent to a computer onboard the vehicle to initiate a sequence of events which enables charging to be commenced.

Furthermore there may be a second switch device associated with the charging head and adapted to be activated during the approach of a vehicle onto the charging head. The second switch device may cause a signal to be sent to a charging station computer to enable communications between a computer onboard the vehicle and the charging station computer to commence.

Preferably, the vehicle contact assembly and the charging head are configured so as automatically to interengage when the vehicle is driven onto the charging head. Thus, the charging connection can be made in a manner which is simple and convenient for the user.

The electrical contact means in the charging head and the vehicle contact assembly may be configured to enable communication between a computer onboard the vehicle and an external computer. In practice, one way of achieving this is to provide three sets of contacts for the receive, transmit and ground lines of a RS 232 serial interface.

Preferably, the charging system is arranged so that power to the vehicle drive means is automatically cut off when the charging head and vehicle contact assembly are interengaged. This feature has the advantage of preventing a vehicle oveshooting a charging head and of preventing a user driving along a serial parking track.

Optionally, the charging system may be arranged so that a vehicle can be energized automatically by external control means for the purpose of changing the vehicle's parking location. This feature enables automatic indexing of the position of vehicles in a serial parking track.

Preferably, the charging system comprises means for sensing increments in the charge level of the vehicle battery. This feature enables a vehicle to be freed for use as soon as its battery is charged to a suitable level e.g 80% of full charge.

Also, the vehicle may comprise means for sensing decrements in the charge level of the vehicle battery and, optionally, the vehicle may comprise means for indicating the battery charge level to the user.

In a preferred embodiment of the present invention, the vehicle contact assembly is mounted on the underside of the vehicle. This feature has the important advantages of obviating the need for overhead charging structures, pantographs etc and of enabling the charging head to be completely shrouded by the vehicle itself during charging thereby increasing safety.

Preferably, one or both of the charging head and the vehicle contact assembly has means arranged so as normally to cover the electrical contact means thereof, the electrical contact means and the covering means being relatively movable during interengagement of the charging head and the vehicle contact assembly so as to expose said electrical contact means. This feature has the advantage that the contacts are normally completely covered and are only exposed when the vehicle is at a charging location. Preferably, the covering means comprises insulating material positioned so as normally to engage the electrical contact means. In this way, the contact means are protected from weather conditions, unauthorised tampering and are kept relatively clean.

In a preferred embodiment, one or both of the charging head and the vehicle contact assembly comprise camming means shaped to engage covering means provided on the other one thereof so as to move the covering means in order to uncover the electrical contact means during interengagement of the charging head and the vehicle contact assembly. The camming means may define a surface inclined relative to an axis along which the charging head and vehicle contact assembly are movable so as to interengage.

In the particular embodiment to be described, the charging head comprises camming means in the form of a relatively short strip member positioned so as to be the first part of the charging head which engages the vehicle contact assembly. The camming means on the charging head may be configured to co-operate with a ramp portion on covering means provided on the vehicle contact assembly.

In the embodiment to be described, the vehicle contact assembly comprises camming means in the form of two parallel edges on spaced parallel flanges. The camming means on the vehicle contact assembly may be configured to co-operate with a front edge of covering means provided on the charging head so as to move the covering means during interengagement of the charging head and the vehicle contact assembly.

Preferably, the vehicle and/or the charging head has associated guide means for aligning the charging head and the vehicle contact assembly relative to one another. The guide means may comprise a converging lead-in zone having a relatively wide mouth and a relatively narrow alignment zone adjacent the lead-in zone. In practice, the guide means may be generally Y-shaped.

A further preferred feature is that the charging system comprises a self-aligning mechanism associated with the charging head and/or the vehicle contact assembly for permitting a degree of play in the relative positions of each of these components so as to facilitate interengagement thereof. The self-aligning mechanism may be configured to permit relative movement of the charging head and the vehicle contact assembly in all three dimensions and/or to permit relative rotation of the charging head and the vehicle contact assembly. In practice, it is envisaged that the self-aligning mechanism will be associated with the charging head although it can be associated with the vehicle contact assembly. Alternatively, self-aligning mechanisms associated with both the charging head and the vehicle contact assembly may be provided.

According to a further aspect of the present invention we provide a charging assembly for an electrically powered vehicle comprising a vehicle contact assembly mounted on the underside of the vehicle and which is adapted to interengage a charging head, the charging head being mounted in a charging location so as to be positioned underneath the vehicle during charging.

According to another aspect of the present invention we provide a charging system for an electrically powered vehicle comprising a vehicle contact assembly mounted on the vehicle and configured for interengagement with a charging head mounted at a charging location wherein the vehicle contact assembly and the charging head each comprise electrical contact means and wherein one or both of the vehicle contact assembly and the charging head have means for normally covering the electrical contact means, the covering means being arranged so that relative movement between the covering means and the electrical contact means occurs so as to expose the electrical contact means as the vehicle contact assembly and charging head are interengaged.

In a further aspect, the invention also provides a control system for electrically powered vehicles comprising means for sensing the position of a parked vehicle and control means adapted to control the power supply to the vehicle drive means so as to enable automatic incremental movement of a vehicle from one parking location to another. This feature may beused to enable automatic shunting of a vehicle along a series of charging heads where a serial parking system is used.

According to the present invention we also provide a charging system for electrically powered vehicles each of which comprises an onboard computer wherein the system is arranged so that when a charging connection is made between the vehicle and charging means the vehicle computer is also thereby connected for communication with an external device.

Finally, the present invention further provides a parking pad of modular construction. This aspect has the advantage of facilitating the construction of parking locations permitting parallel angle and/or serial parking.

Particular embodiments of the present invention will now be described, by way of

example, with reference to the accompanying drawings in which:

Figure 1 is a perspective view of an entrance to a charging station;

Figure 2 is a perspective view of two charging pads arranged for parallel parking;

Figure 3 is a perspective view of charging pads arranged for angle parking;

Figure 4 is a perspective view of a charging head mounted in a charging pad;

Figure 5 is a lengthwise cross-sectional view of a charging head and its self-aligning mechanism;

Figure 6 is a perspective view from above of the self-aligning mechanism;

Figure 7 is a side view of a charging contact shoe;

Figure 8 is a side view, partly in section, of a contact member seated in the contact shoe of Fig. 7;

Figure 9 is a perspective view of three of the contact members of the charging head;

Figure 10 is a perspective view from below of a vehicle contact assembly and guide means mounted on the underside of a vehicle;

Figure 11 is an end view of a vehicle contact assembly;

Figure 12 is a plan view of part of the contact arrangement of the vehicle contact assembly;

Figures 13A–13C are schematic side views of different stages of interengagement of the charging head and the vehicle contact assembly;

Figure 14 is a schematic side view of the charging head interengaged with the vehicle contact assembly;

Figure 15 is a transverse cross-sectional view of a charging head interengaged with a vehicle contact assembly.

Figures 16A and 16B are diagrams of alternative charging circuit arrangements;

Figure 17 is an exploded view of a parking pad.

In the embodiments to be described, a charging system according to the present invention is incorporated in an urban transport system in which electrically powered vehicles are let for hire. The transport system comprises vehicle charging stations at different locations, each vehicle charging station comprising several charging pads. A vehicle can be collected for hire by a user from a charging pad at a vehicle charging station and, after use, can be returned to a charging pad for recharging at the same, or at a different, charging station. The vehicles have motors powered by a heavy duty accumulator of known type.

Referring to Figs. 1–3, each charging station has several charging pads 10 arranged to permit parallel, angle and/or serial parking as desired. Fig. 1 shows the entrance to a charging station and part of a serial parking track. Figs. 2 and 3 illustrate charging pads 10 arranged for parallel and angle parking respectively. The charging pads 10 are of modular construction.

Each charging pad 10 has a charging head 12 arranged so that a vehicle contact assembly provided on the underside of each vehicle 11 engages the charging head 12 when the vehicle 11 is driven onto the charging pad 10 so as to permit recharging of the vehicle battery.

The urban transport system is controlled by a system comprising a central computer in communication with several charging station computers, one at each charging station, and a computer onboard each vehicle 11. The central computer is in duplex communication with each of the charging station computers and is linked to these by a fixed communication network of dedicated lines which are supervised by the central computer. When a vehicle 11 is connected for charging at a charging pad 10, the computer onboard that vehicle 11 is linked temporarily to the charging station computer. The communication link between the charging station computer and the onboard computer is of a multi-drop configuration and each of the onboard computers so linked may be polled in sequence by the charging station computer, after first being identified on arrival by a special polling protocol, to collect data from the onboard computers and to transmit messages to them. Alternatively, hardware may be used to enable communications between the charging station computer and a particular charging pad. In the case of serial parking, it may only be the end charging pads which are regularly polled.

The construction of the charging heads 12 will now be described particularly with reference to Figs. 4–9 and 15.

Each of the charging heads 12 is mounted on a self-aligning mechanism 14 designed to permit movement of the charging head 12 in all three dimensions and to permit rotation of the charging head 12 prior to engagement with a vehicle contact assembly. Each charging head 12 and its associated self-aligning mechanism 14 is mounted at the front part of a charging pad 10 and projects upwardly through a square aperture 16 provided in the charging pad 10. To avoid confusion, for the purpose of this specification, the forward direction is intended to refer to the direction in which a vehicle 11 drives onto a charging head 12.

The charging head 12 is made primarily of sheet steel and comprises a contact carrying support 18 which has a generally arch-shaped upper plate 19 which is curved at the front, and which has four downwardly depending flanges 20–23 shaped to provide a shallow rectangular recess 24 at the front end of the contact carrying support 18 for housing six electrical contact members 25–30. In use, the recess 24 is completely sealed. The electrical contact members 25–30 are made of phos-

phor bronze and are in the form of leaf springs and three each are attached to insulating plates 31 and 32 fixed to the underside of the plate 19. The configuration of the contact members 25–30 will be described in more detail later with reference to Figs. 7 to 9.

The plate 19 of the contact carrying support 18 has a strip of self-lubricating material 33, such as Oilon, secured thereto. The strip 33 runs centrally along the length of the plate 19 and is bevelled at its front and rear edges 34 and 35 respectively. A relatively short strip 36, which is also of self-lubricating material, is attached adjacent the edge 35 of the strip 33 and is angled to provide a camming surface C for a purpose to be described. The strip 36 is attached to a strip 38 of sheet steel which is relatively thick compared to the plate 19 but is of narrow width and which is attached to the underside of the plate 19.

The charging head 12 is rigidly mounted on a base plate 40 by means of front and rear hollow pillars 42 and 44 respectively. The upper end of the rear pillar 44 is welded to the strip 38 and the lower end of the pillar 44 is welded to the base plate 40. The upper end of the front pillar 42 is screwed to the plate 19 and the lower end 45 of the pillar 42 is free to allow electrical leads to be inserted therein and led up through the pillar 42 and out through a notch 46 at the top thereof to provide electrical connections to the contact members 25–30. The pillar 42 is also welded, at a region above its free end 45, to the base plate 40.

A compression spring 48 surrounds the front pillar 42 and abuts a movable cover plate 50 to the front part of which is attached a weather-proofing and insulating layer 52. Advantageously, the layer 52 may have the property of "flowing" around the contact members and around the lowermost edges of the flanges 20–23. The cover plate 50 is also generally arch-shaped but is slightly wider and longer than the plate 19. The spring 48 urges the cover plate 50 against the lowermost edges of the flanges 20–23 of the contact carrying support 18 so as completely to seal the recess 24 housing the contacts 25–30.

Referring to Fig. 7, 8 and 9, the six contact members 25–30 each comprise a leaf spring and are arranged three on each side of the pillar 42. The contact member 27 is shown in side view in Fig. 5. Fig. 9 shows the three contact members 25–27 from the rear. The contact members 28 and 29 are identical to the contact members 26 and 27 and the charging contact members 25 and 30 are also identical to one another.

The contact members 26–29 are each formed from a single strip of phosphor bronze and have a straight rear part 53 contiguous with an arcuate front part 54.

The contact members 26, 27 and 28 are the receive, transmit and ground connections of an RS 232 serial interface enabling communication between the computer onboard the vehicle 11 and the charging station computer. The contact member 29 is for providing a signal from the vehicle battery to a relay associated with the charging head 12 for a purpose to be described.

Contact members 25 and 30 are the charging contacts and each of these is formed additionally with two apertured side flaps 55 which sit in a phosphor bronze contact shoe 58 of similar shape (shown separately in Fig. 7). Each side flap 55 is formed with a relatively large aperture 56. The side flaps 60 of the contact shoe 58 are each provided with a relatively small aperture 62. A conductive pin 64 is inserted through the apertures 56 in the contact members 25 and 30 and through the apertures 62 in their associated contact shoes 58. The contact shoes 58 can thus move laterally relative to their associated contact members 25 and 30 and can rotate slightly relative to the contact members 25 and 30 by virtue of the play provided by the relatively large apertures 56 of the contact members 25 and 30. Hence this arrangement helps to ensure that a good charging connection is made which is desirable because of the relatively high charging current used.

Referring specifically to Figs. 5 and 6, the self aligning mechanism 14 on which the charging head 12 is mounted comprises an upper plate 66 which is shaped to provide an upstanding square part 68 which is smaller than, and is located within, the square aperture 16 in the charging pad 10. The upstanding square part 68 of the upper plate 66 is provided with a relatively large circular aperture 70 towards the rearthereof and a relatively small rectangular aperture 71 towards the front thereof.

The upper plate 66 is secured to a supporting plate 72 the shape of which can best be seen in Fig. 6. The supporting plate 72 has a central sunken recess at the rear end thereof in which is situated a rotatable cylindrical bearing block 74. There is a rectangular aperture 76 towards the front of the supporting plate 72 which underlies the aperture 71 which is of the same size. The supporting plate 72 has downwardly turned side flanges 78 and 80 each of which is pivotally attached to a pair of arms 81, 84 and 82, 83 respectively. The lower ends of the arms 81 and 84 at the rear end of the supporting plate 72 are pivotally connected to a common axle 86 held in blocks 88 and 90 which are secured to a lower base plate 91. The axle 86 is provided with a downwardly depending flange 92 which is positioned adjacent a microswitch 94 of the bellows type so that when the axle 86 rotates clockwise as indicated in Fig. 5, the microswitch is closed.

The lower base plate 91 has side flanges 96, 98 to which are attached the lowermost

ends of the pivot arms 82 and 83. The base plate 91 has an upwardly extending ramp portion 100 at the front part thereof which is contiguous with a relatively short horizontal end portion 102. The end portions 102 of the lower base plate 91 is provided with a stop 103 configured to limit the rearward rotation of the front pivot arm 83.

Two large helical compression springs 104 and 106 are attached between the supporting plate 72 and the lower base plate 91. The springs 104 and 106 are angled so as to bias the supporting plate 72 upwardly and rearwardly relative to the lower base plate 91. A V-shaped support 108 is used to attach the uppermost end of each of the springs 104 and 106 to the underside of the supporting plate 72.

The lower base plate 91 can move laterally by virtue of being mounted on two double-row ball-bearing runners 110 and 112. Each of the runners 110 and 112 comprises two rows 114, 116 of ball-bearings held in position by a cage 118 in an outer race 120. An inner race 122 for each runner 110, 112 is secured to the lower base plate 91. The runner 110 is horizontal and is secured directly to an underlying support 126. The runner 112 is slightly larger than the runner 110 and, in addition, is mounted in an angled fashion on V-shaped support 124 which is welded to the underlying support 126. The side flanges 96 and 98 of the lower base plate 91 each have V-shaped notches 128 to accommodate the angled runner 112. The inner race 122 of the runner 112 is secured to the ramp portion 100 of the lower base plate 91.

The self aligning mechanism 14 is arranged to permit 50mm of lateral movement each side of a notional centre line of the charging head 12 on the runners 110 and 112. The base plate 40 of the charging head 12 is secured to the bearing block 74 so that the charging head can rotate with the bearing block 74. The degree of rotation of the charging head 12 is limited by virtue of the front pillar 42 hitting the sides of the rectangular apertures 71 and 76 in the upper plate 66 and the supporting plate 72 respectively. In practice, it is envisaged that rotation of 15° about the notional centre line will be permitted. The height of the charging head 12 can be reduced by pressing downwardly and forwardly against the force of the springs 104 and 106 causing the pivot arms 81–84 to pivot clockwise as viewed in Fig. 5.

Referring to Figs. 10–12, 14 and 15 the vehicle contact assembly, which is also made from sheet steel, is indicated generally at 130 and comprises a rigid cage 132 and a movable plate 134.

The cage 132 has a top wall 136, side walls 138 and 140 and horizontal contact-carrying flanges 142 and 144 which project inwardly from the side walls 138 and 140 respectively. The side walls 138 and 140 each have two generally square apertues 146 and 148. The side walls 138 and 140 of the cage 132 each have, at their front ends, a lower inclined edge 150 and 152 respectively which form camming edges, the purpose of which will be more fully described later. The rear ends of the side walls 138 and 140 also have similar inclined lower edges.

The flanges 142 and 144 each carry plates 154 and 156 respectively of insulating material. The insulating plates 154 and 156 each carry three copper contact strips so that there are six contact strips 157–162 in all. Each of the contact strips 157–162 is L-shaped (see Fig. 12) to provide an electrical connection portion 164 so that wires need to be attached only to one side of each of the insulating plates 154 and 156.

Referring to Fig. 12, the plate 154 carrying three copper contact strips 157, 158 and 159 is shown. The plate 156 is identical but is rotated through 180° relative to the plate 154 so that the strips 160, 161 and 162 are the other way round than those on the plate 154 in Fig. 2 i.e with the connection portions 164 at the other end. Nylon screws (not shown) are used to help in securing the contact strips and the insulating plate 154 of the flange 142. In addition, the contact strips are adhesively attached to the plate 154. The contact strips 157 and 162 (not shown) are the charging contact strips and are wider than the remaining contact strips 158–161. In practice, the charging strips 157 and 162 are approximately 12mm wide whereas the remaining contact strips 158–161 are approximately 8mm wide. The length of the contact strips can be chosen according to requirements and may be in the region of 250mm.

The movable cover plate 134 has a horizontal body portion 168 and upwardly inclined ramp portions 170 and 172 at the front and rear ends thereof. There are four flanges 174–177 projecting outwardly from the sides of the body portion 168 of the plate 134. The flanges 174–177 project through the apertures 146 and 148 in each of the side walls 138 and 140 of the cage 132. There are four compression springs 180–183, attached between each of the flanges 174–177 and the top wall 136 of the cage 132, biassing the cover plate 134 against the insulating plates 154 and 156 carrying the contact strips 157–162. The cover plate 134 is provided with two strips of weather-proofing and insulating material 186, so that the contact strips 157–162 are normally completely sealed from weather conditions, dirt etc.

A microswitch indicated schematically at 187 is attached to the top wall 136 of the cage 132. The microswitch 187 is of the bellows type and is arranged so as to be open when the cover plate 134 is in the position shown in Figs. 10 and 11 and to close when

depressed by the cover plate 134 as it is lifted upwardly against the force of the springs 180–183 as shown in Fig. 15.

Referring to Fig. 10, the vehicle contact assembly 130 is bolted to a frame 188 attached to the undercarriage of a vehicle 11. The frame 188 comprises two rails 190 and 192 which are parallel along most of their length but which diverge at their front ends. A generally Y-shaped guide member 194 is secured to the front region of the rails 190 and 192 so that the arms of the Y are aligned with the diverging ends of the rails 190 and 192. The guide member 194 has side plates 196 and 198 which are generally vertical in use and an inclined rear plate 200 interconnecting the side plates 196 and 198. The rear plate 200 lies adjacent the ramp portion 170 of the cover plate 134 of the vehicle contact assembly 130. There is a crossbar 202 connected to the frontmost portions of the rails 190 and 192 and the side plates 196 and 198 of the guide member 194.

The converging part of the guide member 194 forms a lead-in section having a relatively wide mouth. The remainder of the guide member forms a parallel-sided alignment section.

Referring to Fig. 16A the various components are designated by the following reference numerals:

Vehicle computer—204
Charging station computer—205
Vehicle Battery—206
Charge level monitor—208
Charge current limiter—210
Relay—212
Safety isolating contacts—214
Charge current bus bar—216

The microswitch 94 associated with the charging head 12 and the microswitch 187 associated with the vehicle contact assembly 130 are also shown in Fig. 16A.

The line labelled I represents the interface between the contact members 25–30 of the charging head 12 and the contact strips 157–162 of the vehicle contact assembly 130. The lines representing the various contacts are not shown in the same order as the contacts are actually arranged as shown for example in Fig. 15.

The circuitry is arranged so that no power is supplied to the charging contact members 25 and 30 of the charging head 12 unless a vehicle 11 is present at the charging head 12. When a vehicle 11 arrives at a charging head 12 the microswitch 187 informs the vehicle computer 204 when the vehicle contact assembly 130 and the charging head 12 are interengaged. The vehicle computer 204 then receives a signal from the charge level monitor 208 indicating whether the battery 206 requires charging. If it does, the vehicle computer 204 sends a signal causing the relay 212 to be energized so that a +12V signal from the battery 206 is sent to the safety isolating contacts 214 so as to energize these contacts. This results in charging current from the bus bar 216 being supplied via the charging contacts to the battery 206 via a charging current limiter 210. The charging current limiter limits the charging current to a maximum of 30A.

The bus bar 216 is common to several charging heads 12 and supplies a minimum direct current of 30A to each charging head 12 when required. It can be seen that the safety isolating contacts 214 ensure that no charging current supplied to the charging head 12 unless a vehicle 11 is present.

As the vehicle contact assembly 130 of the vehicle 11 engages the charging head 12 the microswitch 94 associated with the charging head 12 is activated which informs the charging station computer 205 of the presence of the vehicle 11. This enables communications via the RS 232 interface between the charging station computer 205 and the vehicle computer 204.

Referring to Fig. 16B an alternative arrangement is shown in which there is an individual charger 218 associated with each charging head 12. Mains current is supplied to the charger 218 when a solid state relay 220 is energized on receipt of a 12V signal from the vehicle battery. Therefore, in this arrangement, it is the solid state relay 220 which ensures that no charging current is supplied to the charging contact members of the charging head 12 unless a vehicle is present at the charging head.

Referring to Figs. 1–3 and 17, each parking pad 10 is of modular construction and comprises ground fixed sleepers 222 which, in use, are secured to V-section cast connectors 224. The cast connectors 224 are secured to generally straight channel-section pieces 226 and to a generally U-shape channel-section piece 228 which defines the tip of the charging pad 10. Cover pieces 230, 232 and 234 are secured to the channel-section pieces 226 and 228. As an alternative, for a permanent charging pad 10, concrete or bitumin may be used instead of removable cover pieces. The frontmost cover piece 230 comprises the aperture 16 for receiving a charging head 12. Underlying the aperture 16 is a charging head junction box 236 adjacent a service duct 238 through which electrical cables are led. A parallel-sided drain cover 240 (see Fig. 2) runs alongside the service duct 238. In Fig. 17, a service duct section 242 and a drain cover 244 specifically configured for use in angle parking are also shown.

In use, when a vehicle 11 is on hire, the charge state of the vehicle battery 206 is sensed by the charge level monitor 208 associated with the onboard computer 204. The computer 204 is powered from the vehicle battery 206. The battery voltage measured is compared against reference "low" and

"dead" limits. The "low" limit indicates an urgent need to recharge and, in that event, further use of the vehicle will only be permitted at reduced power. An audible warning may be issued by a voice synthesizer within the vehicle 11 when a "battery low" condition is soon to be reached. If the battery voltage has reached the "dead" limit, the onboard cokputer prevents further use of the vehicle 11, outputting BATTERY DEAD on the display provided, turning off the vehicle motor and emitting an audio message to the user. In practice, a battery reserve may be available. The battery reserve may only be made available to the possessor of an authorisation "key" such as a service engineer. The audible warning mentioned above may simply be a bleep and/or a visual warning may be given using a display within the vehicle.

In the event that charging of the vehicle battery is sensed when the vehicle 11 is not at a charging pad 10, the onboard computer 204 acts to operate an emergency beacon.

On returning to a charging station, the user drives the vehicle 11 onto a charging pad 10 causing the vehicle contact assembly 130 to interengage a charging head 12 for recharging the vehicle battery. Details of the way in which the vehicle contact assembly 130 and the charging head 12 interengage as the vehicle 11 moves forward will now be described with reference particularly to Figs. 13A–C and 14.

As the vehicle 11 is driven onto the charging pad 10, the wheels of the vehicle 11 will be roughly guided by the sides of the charging pad 10. The top of the charging head 12 is initially higher than the bottom of the vehicle contact assembly 130 so that the Y-shaped guide member 194 on the underside of the vehicle 11 catches the front of the charging head 12. If the charging head 12 is to one side of its desired position, that particular side of the movable cover plate 50 of the charging head is guided against the corresponding side plate 196 or 198, as appropriate, of the guide member 194 of the vehicle contact assembly, causing rotation and/or lateral movement of the charging head 12. In this way, the charging head is lined up for entry into the parallel alignment section of the guide member 194 at which point it is then properly aligned ready for interengagement with the vehicle contact assembly 130.

Subsequently, the camming surface C of the inclined short strip 36 on the charging head 12 comes into contact with the inclined rear plate 200 of the guide member 194 so that further forward movement of the vehicle 11 causes forward depression of the charging head 12 against the force of the springs 104 and 106 of the self-aligning mechanism 14. This corresponds to the positions shown in Fig. 13A. During forward movement of the vehicle 11, the inclined lower edges 150 and 152 of the side walls 138 and 140 of the cage 132 of the vehicle contact assembly 130 both come into contact with a point along the curved front edge of the movable cover plate 50 of the charging head 12. Further forward movement of the vehicle 11 results in the cover plate 50 being forced downwardly against the force of the spring 48 by the lower inclined edges 150 and 152 so as to expose the six contact members 25–30 of the charging head 12. In Fig. 13B the front of the cover plate 50 has already been depressed.

The camming surface C of the short strip 36 at the rear of the charging head 12 comes into contact with the underside of the ramp portion 170 at the front of the horizontal body portion 168 of the movable cover plate 134 of the vehicle contact assembly 130 (as shown in Fig. 13B) so that further forward movement of the vehicle causes the movable cover plate 134 to be lifted against the force of the springs 180–183. Thereby the six contact strips 157–162 on the insulating plates 152 and 154 are exposed.

During interengagement of the vehicle contact assembly 130 with the charging head 12, the inclined lower front edges 150 and 152 on the cage 132 of the vehicle contact assembly 130 initially depress the rear portion of the movable plate 50 of the charging head 12 and then, at some point during their travel along the plate 50 they are sufficiently close to the spring 48 that the rear of the plate 50 rotates upwardly around the lower corners of the edges 150 and 152 until the plate 50 lies parallel and against the bottom edges of the side walls 138 and 140 of the cage 132 as shown in Fig. 13C.

Likewise, during interengagement, the short strip 36 at the front of the charging head 12 initially lifts the front portion of the movable plate 134 of the vehicle contact assembly 130 which eventually rotates around the top edge of the short strip 36 so as to lie parallel with and against the strip 33 at the top of the charging head 12 as shown in Fig. 14.

As the charging head 12 and the vehicle contact assembly 130 move together, the contact carrying flanges 142 and 144 of the cage 132 arrive underneath the contact carrying support 18 of the charging head 12 so that the contact members 25–30 of the charging head 12 engage the contact strips 157–162 of the vehicle contact assembly 130. As shown in Fig. 15, the contacts are held together under the combined action of the four springs 180–183 of the vehicle contact assembly 130 which urge the cage 132 upwardly, and the spring 48 of the charging head 12 which also urges the movable plate 50 of the charging head upwardly so as to abut the underside of the cage 132 of the vehicle contact assembly 130.

During interengagement, as the charging head 12 begins to be depressed, the micro-

switch 94 senses movement of the pivot arm 84 and sends a signal to the charging station computer 205. In this way, the charging station computer is informed that a vehicle 11 has just arrived at the charging pad 10. Subsequently, as the movable cover plate 134 of the vehicle contact assembly 130 is lifted during engagement, the microswitch 187 is activated causing the onboard computer 204 to send a signal, after a short delay and if charging is required, which causes a 12V signal to be supplied from the vehicle battery 206, via the contacts 161 and 29 on the vehicle contact assembly 130 and the charging head 12 respectively, to the charging head 12 as described above with reference to Figs. 16A and 16B. The charging current supplied is a minimum current of 30 amps at a voltage of 24V. The charging current can be as much as 100A or more especially when serially parked vehicles are to be charged from common bus bar 216.

At this point, the onboard computer 204 disconnects the power supply to the vehicle motor and applies an automatic brake.

When the vehicle contact assembly 130 of the vehicle 11 interengages the charging head 12, after a short delay, although a delay which is longer than that preceding the start of charging communications between the onboard computer 204 and the charging station 205 computer commence via a serial communications interface as described above. Whether or not a vehicle 11 is present, the charging station computer regularly sends polling messages to the charging head 12.

During recharging, the charge level monitor 208 in the vehicle 11 senses increments in the charge level of the vehicle battery 206 and, when a predetermined charge level is reached e.g 80% of the full charge, the vehicle is ready for hire. If not hired, charging continues. When hired, charging is stopped before the vehicle drive means is enabled.

The rate at which the battery 206 is recharged depends on the initial level of charge and the condition of the battery. The charge current limiter 210 ensures that vehicle battery 206 is not subjected to an excess charging current. If desired where serial parking is adopted, the arrangement may be that vehicles are only charged when they reach the charging head at which they will rest for some time i.e charging will not take place during automatic indexing of the vehicle along a serial parking line. Alternatively, the system may be arranged so that charging does take place during automatic indexing.

The charge level at which a vehicle is released for hire can be decided according to requirements. For example, if only a short journey is envisaged a charge level of 50% of the full charge may be sufficient.

The vehicle 11 can be driven forwardly or reversed off the charging head 12 as convenient. If the vehicle 11 is reversed off the charging head 12 the reverse sequence of events occurs as when the vehicle 11 is being driven onto the charging head 12. As the cage 132 of the vehicle contact assembly 130 is gradually removedf, the movable cover plate 50 of the charging head 12 moves upwardly due to the force of the spring 48 and seals the contact members 25–30 of the charging head 12. Likewise, during disengagement, the movable cover plate 134 of the vehicle contact assembly 130 moves downwardly under the force of the springs 180–183 so as to cover the contact strips 157–162.

The charging system described above has the advantage of being very robust, being able to withstand substantial impact forces and harsh weather conditions, and of operating in a safe, reliable and convenient manner.

It will be appreciated that modifications can be made to the charging system described above.

In particular, the strip 36 at the rear of the charging head 12 which provides a camming surface could be replaced by a roller or other suitable camming means. If desired, the guide means, instead of being mounted on the vehicle, could be associated with the charging head. Likewise, either one or both of the charging head and vehicle contact assembly may be provided with a self-aligning mechanism of some kind.

It is envisaged that the charging head 12 may be mounted on a flat plate the edges of which simply abut the underside of the edge regions of the charging pad 10 which define the aperture 16, rather than providing the upper plate 66 which has an upstanding square part 68.

Where serial parking is adopted, the charging station computer may poll the charging heads at the ends of the parking line so that, when a vehicle arrives at the line it is automatically indexed along the charging heads in the line until it reaches the forwardmost vacant space in the line. This automatic indexing is achieved by software control involving signals being sent from the charging station computer to the computer onboard the vehicle to enable the vehicle drive means. During automatic indexing the charging heads in the parking line will also be polled by the charging station computer.

Instead of providing a direct link for computer communications an rf connection using inductive loops may be provided to reduce interference.

It is envisaged that electrical trace heating may be provided to maintain the charging head clear of snow and ice if necessary.

If desired, the vehicle contact assembly may be mounted other than on the underside of the vehicle, for example, on the side or roof of the vehicle in which case the charging heads at a charging station would be posi-

tioned accordingly.

It should be appreciated that the interengaging assembly herein described in the form of a charging head and vehicle contact assembly may also have applications in other fields where it is desired releasably to attach two articles to one another for a particular purpose.

CLAIMS

1. A system for charging an electrically powered vehicle comprising a vehicle contact assembly mounted on the vehicle and a charging head associated with charging means, the vehicle contact assembly and the charging head both comprising electrical contact means, wherein the vehicle contact assembly and the charging head are interengagable so as to provide a charging connection and wherein the system is arranged so that the interengagement of the vehicle contact assembly with the charging head causes electrical power to be supplied to the charging head from the charging means to initiate charging.

2. A charging system according to claim 1 wherein the vehile comprises means for supplying a signal to the charging head to initiate charging following interengagement of the vehicle contact assembly and the charging head.

3. A charging system according to claim 2 wherein the vehicle is powered from a battery and wherein the signal supplying means comprises the vehicle battery.

4. A charging system according to claim 2 or claim 3 wherein the means for supplying said signal is controlled by a computer onboard the vehicle.

5. A charging system according to any preceding claim comprising safety switch means associated with the charging head, which safety switch means is closable when the vehicle contact assembly interengages the charging head so as to complete a charging circuit.

6. A charging system according to claim 5 wherein the safety switch means comprises a relay.

7. A charging system according to any preceding claim wherein the vehicle is powered from a battery and comprises a charge level monitor for sensing the battery charge level, which charge level monitor is connected to a computer onboard the vehicle.

8. A charging system according to any preceding claim comprising a first switch device associated with the vehicle contact assembly and adapted to be activated during interengagement of the vehicle contact assembly and the charging head.

9. A charging system according to claim 8 wherein the first switch device causes a signal to be sent to a computer onboard the vehicle to initiate a sequence of events which enables charging to be commenced.

10. A system according to any preceding claim comprising a second switch device associated with the charging head and adapted to be activated during the approach of a vehicle onto the charging head.

11. A charging system according to claim 10 wherein the second switch device causes a signal to be sent to a charging station computer to enable communications between a computer onboard the vehicle and the charging station computer to commence.

12. A charging system according to any preceding claim wherein the vehicle contact assembly and the charging head are configured so as automatically to interengage when the vehicle is driven onto the charge head.

13. A charging system according to any preceding claim wherein the electrical contact means in the charging head and the vehicle contact assembly are configured to enable communication between a computer onboard the vehicle and an external computer.

14. A charging system according to any preceding claim which is arranged so that power to the vehicle drive means is automatically cut off when the charging head and vehicle contact assembly are interengaged.

15. A charging system according to any preceding claim which is arranged so that a vehicle can be energized automatically by external control means for the purpose of changing the vehicle's parking location.

16. A charging system according to any preceding claim comprising means in the vehicle for indicating the battery charge level to the user.

17. A charging system according to any preceding claim wherein the vehicle contact assembly is mounted on the underside of the vehicle.

18. A charging system according to any preceding claim wherein one or both of the charging head and the vehicle contact assembly has means arranged so as normally to cover the electrical contact means thereof, the electrical contact means and the covering means being relatively movable during interengagement of the charging head and the vehicle contact assembly so as to expose said electrical contact means.

19. A charging system according to claim 18 wherein the covering means comprises insulating material positioned so as normally to engage the electrical contact means.

20. A charging system according to claim 18 or claim 19 wherein the covering means comprises a spring biassed plate.

21. A charging system according to any of claims 18–20 wherein one or both of the charging head and the vehicle contact assembly comprise camming means shaped to engage covering means provided on the other one thereof so as to move the covering means in order to uncover the electrical contact means during interengagement of the

charging head and the vehicle contact assembly.

22. A charging system according to claim 21 wherein the camming means defines a surface inclined relative to an axis along which the charging head and vehicle contact assembly are relatively movable so as to interengage.

23. A charging system according to claim 22 wherein the charging head comprises camming means in the form of a ramp member positioned so as to be the first part of the charging head which engages the vehicle contact assembly.

24. A charging system according to any of claims 21–23 wherein the charging head comprises camming means configured to co-operate with a ramp portion on covering means provided on the vehicle contact assembly.

25. A charging system according to any of claims 22–24 wherein the vehicle contact assembly comprises camming means defined by two parallel edges on spaced parallel flanges thereof.

26. A charging system according to any of claims 21–25 wherein camming means are provided on the vehicle contact assembly and are configured to co-operate with a rear edge of covering means provided on the charging head so as to move the covering means during interengagement of the charging head and the vehicle contact assembly.

27. A charging system according to any preceding claim wherein the vehicle and/or the charging head has associated guide means for aligning the charging head and the vehicle contact assembly relative to one another.

28. A charging system according to claim 27 wherein the guide means comprises a converging lead-in zone having a relatively wide mouth and a relatively narrow alignment zone adjacent the lead-in zone.

29. A charging system according to claim 27 or claim 28 wherein the guide means is generally Y-shaped.

30. A charging system according to any preceding claim comprising a self-aligning mechanism associated with the charging head and/or the vehicle contact assembly for permitting a degree of play in the relative positions of each of these components so as to facilitate interengagement thereof.

31. A charging system according to claim 30 wherein the self-aligning mechanism permits relative movement of the charging head and vehicle contact assembly in all three dimensions.

32. A charging system according to claim 30 or claim 31 wherein the self-aligning mechanism permits relative rotation of the charging head and the vehicle contact assembly.

33. A charging system according to any of claims 30–32 wherein the self-aligning mechanism is associated with the charging head.

34. A charging system according to any preceding claim comprising means for biassing together the electrical contact means on the vehicle contact assembly and the charging head when these components are interengaged.

35. A charging system substantially as herein described with reference to and as illustrated in the accompanying drawings.

36. A vehicle contact assembly for use in a charging system according to any preceding claim.

37. A vehicle contact assembly substantially as herein described with reference to and as illustrated in the accompanying drawings.

38. An electrically powered vehicle comprising a vehicle contact assembly for use in a charging system according to any preceding claim.

39. A vehicle substantially as herein described with reference to and as illustrated in the accompanying drawings.

40. A charging head for use in a charging system according to any preceding claim.

41. A charging head substantially as herein described with reference to and as illustrated in the accompanying drawings.

42. A charging assembly for an electrically powered vehicle comprising a vehicle contact assembly mounted on the underside of the vehicle and which is adapted to interengage a charging head, the charging head being mounted in a charging location so as to be positioned underneath the vehicle during charging.

43. A charging system for an electrically powered vehicle comprising a vehicle contact assembly mounted on the vehicle and configured for interengagement with a charging head mounted at a charging location wherein the vehicle contact assembly and the charging head each comprise electrical contact means and wherein one or both of the vehicle contact assembly and the charging head have means for normally covering the electrical contact means, the covering means being arranged so that relative movement between the covering means and the electrical contact means occurs so as to expose the electrical contact means as the vehicle contact assembly and charging head are interengaged.

44. A control system for electrically powered vehicles comprising means for sensing the position of a parked vehicle and control means adapted to control the power supply to the vehicle drive means so as to enable automatic movement of a vehicle from one parking location to another.

45. A charging system for electrically powered vehicles each of which comprises an onboard computer wherein the system is arranged so that when a charging connection is made between the vehicle and charging means the vehicle computer is also thereby connected for communication with an external de-

vice.

46. A parking pad of modular construction.

47. A control system substantially as herein described with reference to and as illustrated in the accompanying drawings.

48. A parking pad substantially as herein described with reference to and as illustrated in the accompanying drawings.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd, Dd 8991685, 1987.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.